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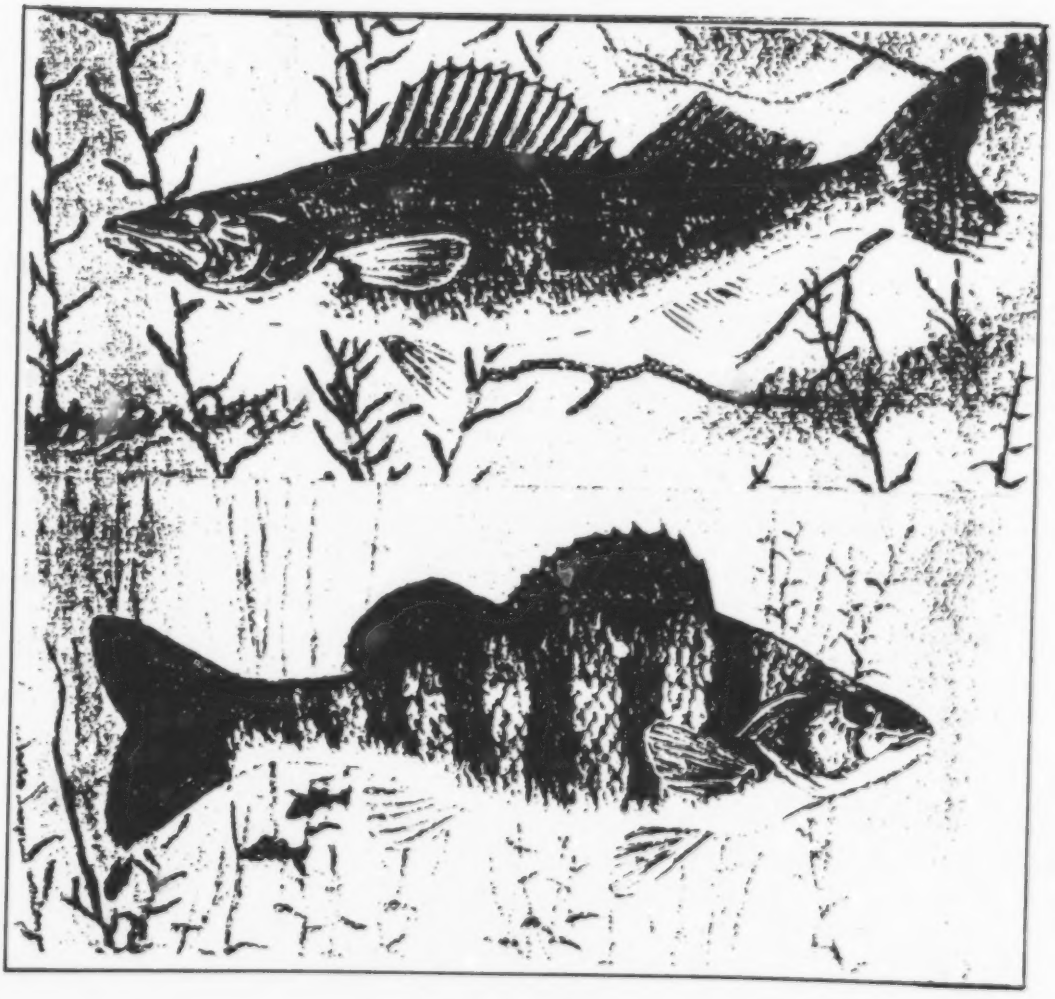
An Assessment of Stocked Fish Populations in Smuts Lake

Technical Report 89-2



AN ASSESSMENT OF STOCKED FISH POPULATIONS IN SMUTS LAKE

BY

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EXECUTIVE SUMMARY

SITUATION

Stocking of walleye in Saskatchewan has traditionally been done with newly hatched fry. However, lack of success with previous stocking has shifted the focus in recent years from stocking with fry to fingerlings. Fingerling stocking was first carried out in 1982 with only 6 910 fingerlings being released into four lakes. The number of fingerlings produced has since increased substantially: in 1988, a total of 387 340 pond-reared fingerlings were stocked in 16 water bodies; in 1989, 13 lakes were stocked with a total of 353 130 fingerlings. The success of the fingerling stocking program needs to be evaluated in order to justify continuous walleye rearing pond operations.

In addition to the study conducted on Greig Lake, Smuts Lake (E1/2 33-40-1-W3 and SW3, SE4-41-1-W3, approximately 65 km northeast of Saskatoon) was chosen in 1988 as an experimental lake to compare success of walleye fry versus fingerling stocking. On May 27, 1988, 100 000 walleye fry were stocked in Smuts Lake, and in August, 4 160 Codette Pond-reared walleye fingerlings were released (both groups of walleye came from the same source, and were stocked as fry on the same day).

Smuts Lake was stocked with adult yellow perch in 1982. The yellow perch has since successfully reproduced and established a large population in the lake. The walleye introduced may serve as predators to control overpopulation and stunted growth in the yellow perch.

Samples of walleye and yellow perch were obtained regularly from Smuts Lake during open water seasons in 1988 and 1989 for growth and stomach content analyses, as well as for population estimates.

The present report documents the results of the walleye stocking and the current status of the yellow perch population in the lake.

RESULTS

Smuts Lake has a water area of approximately 47 ha. Water level of the lake has increased by approximately 1.5 m in recent years. The present mean depth of the lake is 4.1 m and the maximum depth is 6 m.

Smuts is a sulphate dominated subsaline lake (total dissolved, 1 690 mg/L).

Smuts Lake is productive. It has abundant bottom organisms and zooplankton, as well as brook sticklebacks which are important food sources for the stocked walleye and yellow perch.

Although winterkills occurred in the past, they have not happened since the yellow perch were introduced in 1982. Measurements of winter dissolved oxygen levels indicate that they are adequate for the survival of walleye.

Mark and recapture data indicate that Smuts Lake now has approximately 81 200 subadult and adult yellow perch. About 32% by length and 16% by weight of the these yellow perch are considered to be of angling size (i.e. larger than 18 cm in length or 100 g in weight).

Results of stomach content analysis indicate that the yellow perch fed predominantly on aquatic insect larvae and amphipods. Walleye juveniles and fingerlings were not found in their diet.

The growth of the walleye fry stocked in Smuts Lake is probably among the fastest recorded in Saskatchewan waters. During the first growing season in the lake, they grew at a rate of 1.2 mm/day in total length and 272 mg/day in weight, reaching 149 mm in length and 28.2 g in weight by the end of the season (125 days after stocking). By comparison, the same batch of walleye fry stocked in Codette Pond grew at a rate of 1.2 mm/day in length and 63 mg/day in weight during their first 50 days in pond. However, their average daily growth dropped considerably before harvest. After being restocked into Smuts Lake they grew at rates of

0.65 mm/day and 151 mg/day and attained an average size of only 108 mm in length and 11.16 g in weight by the end of the season. The drop in growth in the Codette Pond walleye before harvest is attributable to lack of an adequate food supply in the pond.

Very little growth took place in the fall and winter for both groups of walleye.

Growth resumed at the beginning of the next summer with much larger gains in weight than in length. The average daily gains in length were 1.04 mm for Smuts Lake fish and 1.25 mm for Codette Pond fish. The corresponding weight gains were 950 mg and 884 mg. Although the growth of Codette walleye was slower at the time of restocking, it increased considerably in the second growing season. The growth curve suggests that by the end of the second growing season, the restocked Codette Pond walleye would have almost caught up with the Smuts Lake walleye.

Based on mark and recapture data of Codette Pond walleye, 58 000 of the 100 000 fry originally stocked in Smuts Lake had survived to August 4, 1988. The survival of the restocked fingerlings can not be assessed from the present data. However, there is evidence to suggest that mortalities of these two groups of walleye remained similar throughout the study period.

The key factor to the success of fry stocking in Smuts Lake is likely the presence of very abundant edible zooplankton and other food bases throughout the entire growing season. Under such circumstances, stocking of fingerlings has no advantages over fry stocking.

Based on the findings of the study, it is recommended that:

1. Investigation on the food supply in the receiving lake be conducted before walleye stocking. If food supply is adequate for newly hatched walleye fry, stocking should be done with fry rather than fingerlings.

2. Harvest of walleye fingerlings from rearing ponds be carried out before their growth begins to decline due to lack of food.

3. The walleye in Smuts Lake be managed as an additional angling species, as well as a predatory species to control overpopulation and stunted growth in the yellow perch.

4. Angling of yellow perch in Smuts Lake be encouraged.

5. Winter oxygen levels in the lake be monitored frequently, and appropriate measures (e.g. snow removal, installation of an aerator) be taken to prevent winter

kill when oxygen levels approach the critical level of 2.6 mg/l.

6. Monitoring of the growth and survival of the stocked walleye be continued.

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1. INTRODUCTION

Smuts Lake is located in E1/2 33-40-1-W3 and SW3, SE4-41-1-W3. Its center is approximately at 52°29' Lat. 106°05' Long. The lake is about 65 km northeast of Saskatoon and is accessible via highway No. 41 (Fig. 1).

A regional park (Alvena Centennial Park) was established in 1967 at the northwest corner of the lake. Recreational activities were limited to picnicking, swimming and boating. There was no sport fishing. Periodic winterkills prevented sport fishes from surviving in the lake.

In an attempt to provide local residents with angling opportunities, the Fisheries Branch stocked the lake with 15 000 rainbow trout fingerlings on March 26, 1968. The trout survived the summer, but succumbed to low levels of oxygen which occurred in the winter. In May of 1969 the lake was again stocked with trout fingerlings (10 000 rainbow and 1 000 brook). Similarly, the trout did well in the summer, but low dissolved oxygen levels occurring in the winter resulted in a complete winterkill.

No other fish stocking program was carried out until 1982, when 3 450 adult yellow perch were introduced.

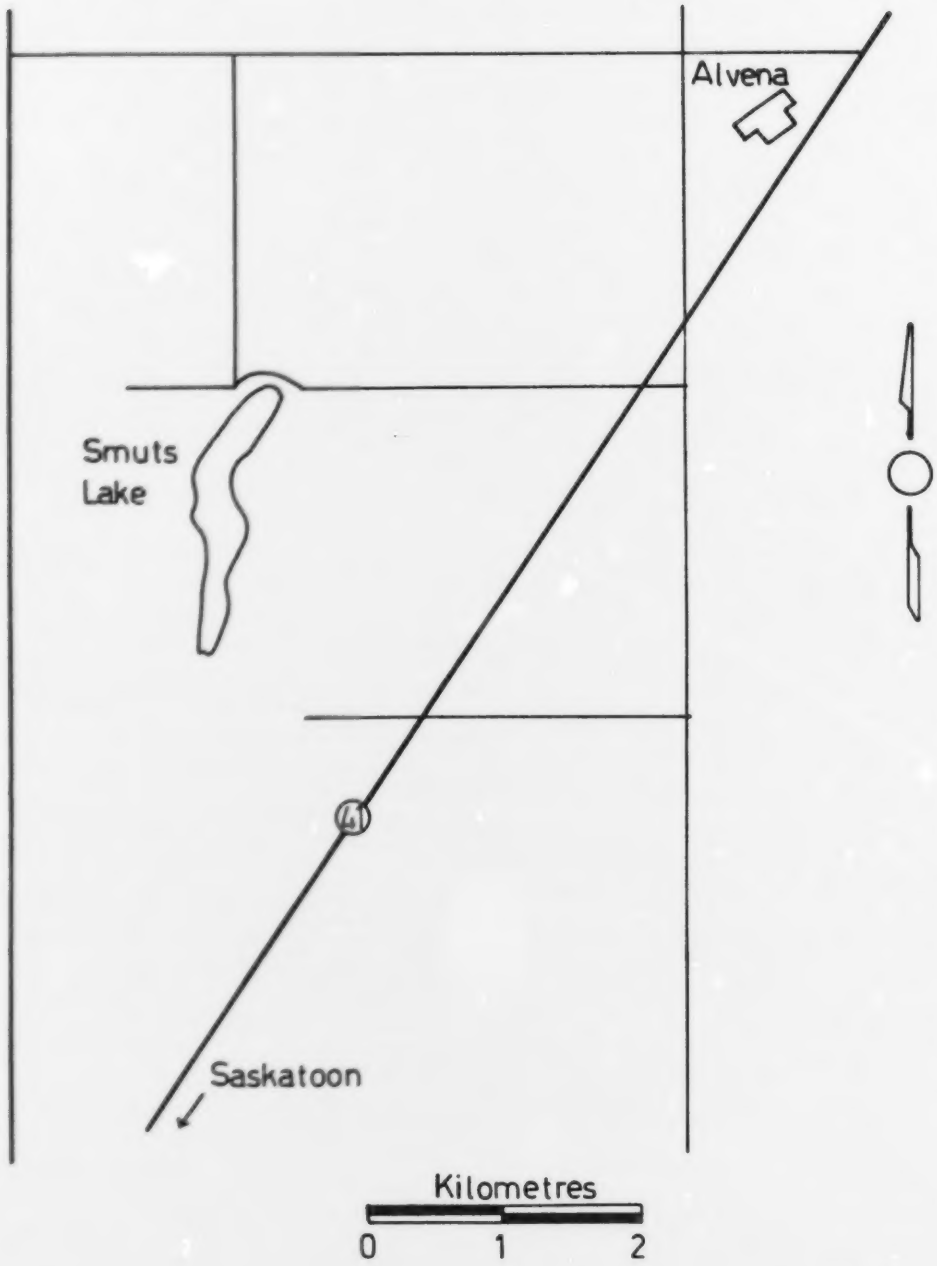

Fig. 1 Location of Smuts Lake.

Abandoned park facilities suggest that Smuts Lake is no longer used extensively by local residents for recreation. The successful establishment of a yellow perch population from the 1982 stocking has provided local residents, as well as people from the Saskatoon area with an angling opportunity. This will perhaps revive the recreational use of the lake.

In 1988, the lake was used as an experimental lake to compare success of walleye fry versus fingerling stocking as a means of evaluating rearing pond operations: in May 100 000 walleye fry were stocked, and in August, 4 160 pond-reared walleye fingerlings were released. The walleye introduced may serve as predators to control overpopulation and stunted growth in the yellow perch. If winterkill does not occur, the walleye will supply anglers with an alternative angling species.

The objective of this report is to assess the current status of the yellow perch population and the result of the walleye stocking program in Smuts Lake. The data will form baseline information for assessing the impact of perch as predators on walleye fry and fingerlings, as well as the impact of walleye on the perch population.

2. THE LAKE AND ITS DRAINAGE BASIN

2.1 The Drainage Basin

The drainage basin of Smuts Lake is gently rolling agricultural land with dark brown soil. The maximum altitude in the area is approximately 556 m above sea level. The altitude of the lake is about 497 m above sea level. The lake is situated in a small ravine and has steep slopes along most of its shore line.

Smuts Lake is in the South Saskatchewan River watershed, but it has no permanent inflow and outflow. The lake depends on runoff from the drainage area as its major source of water supply. Levels of the lake may fluctuate from one year to another, depending largely on the amount of runoff.

2.2 Morphometry of the Lake

Smuts Lake is long and narrow. It has a maximum length (roughly NE-SW orientation) of about 2 km and a maximum width of 310 m. Its mean width is 240 m.

The lake was sounded in 1984 by the Sports Fish Unit of the Fisheries Branch. Based on the sounding map (Fig. 2), water area and volume in each depth zone of the lake were calculated as follows:

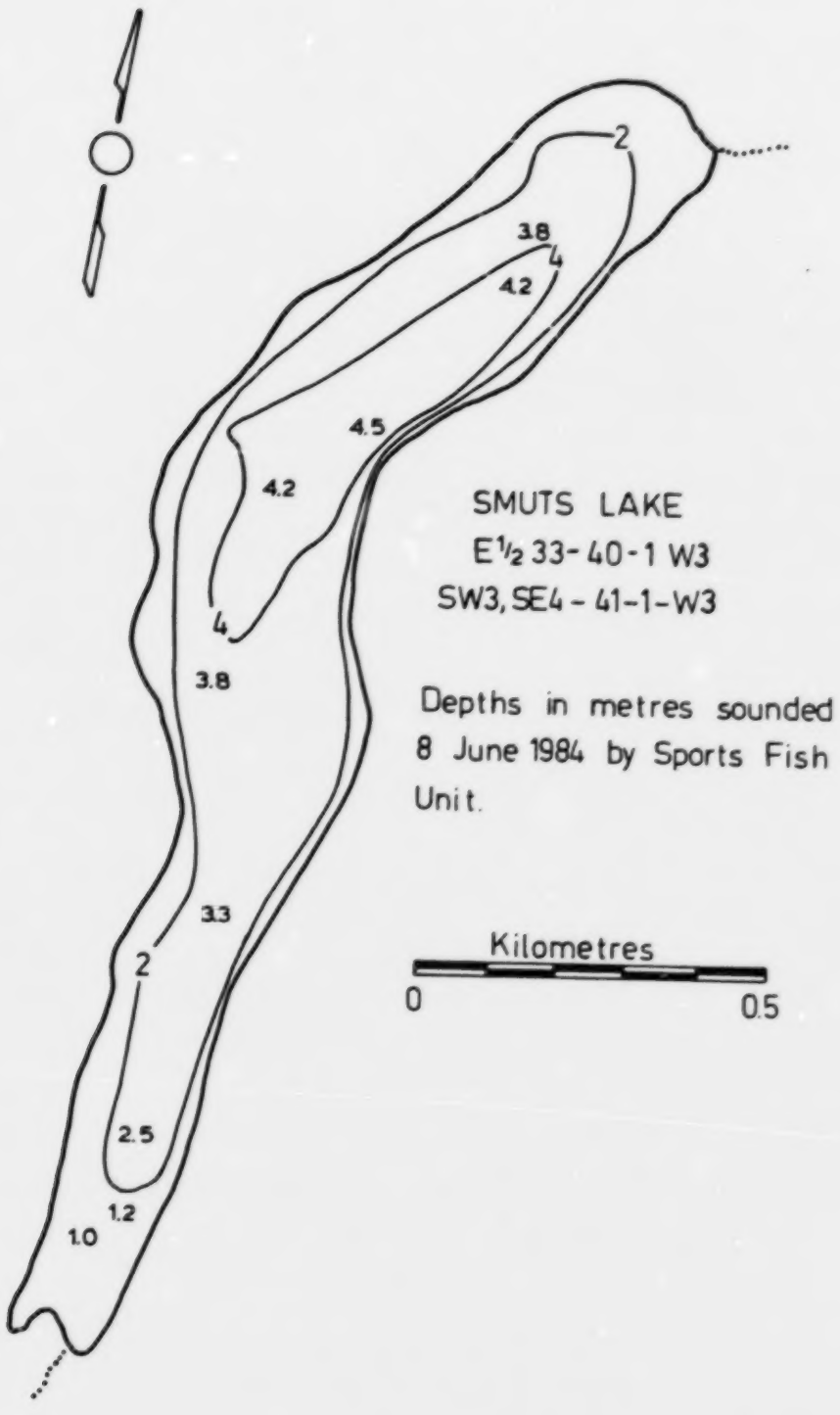

Fig. 2 Bathymetric map of Smuts Lake.

Depth zone (m)	Area		Volume	
	Ha	%	$x10^3m^3$	%
1 -2	12.7	27.0	761	61.3
2- 4	25.8	54.9	399	32.2
>4	8.5	18.1	80	6.5
Total	47.0	100.0	1240	100.0

Smuts Lake had a mean depth of 2.6 m and a maximum depth of 4.5 m when first sounded in 1984. The lake level has since increased by about 1.5 m. The current maximum depth is about 6 m.

2.3 Chemical Characteristics of the Lake

An analysis of the major chemical constituents in Smuts Lake (see table below) indicates that it is a sulphate dominated subsaline lake (Hammer 1986). It has a high total alkalinity and high concentrations of magnesium and sodium.

Constituent	Concentration*
Total dissolved solids	1690
Specific conductance, µS/cm	2010
Total alkalinity as $CaCO_3$	302
Total hardness as $CaCO_3$	860
Bicarbonate	203
Carbonate	82
Chloride	30
Sulphate	864
Calcium	59
Magnesium	174
Potassium	40
Sodium	148
Silica	11

**Analyzed in 1968 by Saskatchewan Research Council. All units in mg/L, except otherwise indicated.*

3. METHODS

3.1 Stocking of Walleye Fry and Fingerlings

On May 27, 1988, 100 000 three-day old walleye fry (based on enumeration of eyed eggs) were transferred from the hatchery at Fort Qu'Appelle and stocked into Smuts Lake at two locations in the open water area. These fry came from the same batch of fry that were stocked on the same day into Codette Rearing Pond (see Arsenault (1988) for details of stocking).

On August 4, 1988, 4 819 walleye fingerlings were trapped from Codette Pond, marked by removing the left pelvic fin, and transported in a 450 L-capacity tank to Smuts Lake and released. During transit (taking 2.5 hours),

the water in the tank was supersaturated with oxygen and its temperature maintained at 17°-18°C with block ice. Upon arrival at Smuts Lake the temperature in the tank was 18°C while that in the lake was 21°C. The temperature in the tank was raised gradually by adding lake water. Before release, the fish were checked carefully to remove all dead and weak individuals. A total of 659 were removed and 4 160 were released alive. The mortality (14%) was believed to be caused by handling, particularly during trapping and fin clipping at warm temperature (20°C).

3.2 Limnological Observations and Biological Sampling

A YSI Model 57 dissolved oxygen meter was used to monitor oxygen and temperature profiles near the deepest area of the lake. The pH of surface water was determined with a portable pH meter. Secchi disc transparencies were measured with a 20 cm diameter all white Secchi disc.

Water samples for zooplankton standing crop determinations were collected with a plankton trap from the top 0.5 m of water. The trap was 0.5 m long and had a volume of 10 L. During each sampling, five samples (a total of 50 L) were collected from various parts of the lake. The water collected was filtered through a Wisconsin-type plankton net

made of No. 20 bolting silk. The concentrated samples were preserved in a 5% formaldehyde solution.

Various gear, including monofilament gillnets (various lengths of 25, 38, 51 and 76 mm stretched mesh), trapnets, and a seine, were used to sample fish. A random sample of the catch was taken during each sampling and preserved immediately in 5% formaldehyde for length, weight and stomach content analyses. Length was measured to the nearest mm, whereas weight was determined to the nearest g, 0.1 g, or 0.01 g, depending on size of the specimen.

Mark and recapture techniques described in Ricker (1975) were used to estimate the populations of yellow perch and walleye in the lake. Walleye stocked as fry were sampled and marked later by removing the right pelvic fin, whereas walleye stocked as fingerlings (from Codette Pond) were all marked by clipping the left pelvic fin before release. A total of 666 yellow perch were marked by left pelvic fin clip and released on June 17, 1988. A total of 886 walleye were right pelvic fin clipped during the summer of 1988 (see Appendix 1 for details).

Sampling was conducted in the summer of 1989 to recapture previously marked fish and to obtain samples for growth determination.

4. RESULTS

4.1 Selected Limnological Data

Profiles of temperature and dissolved oxygen in the water column (Table 1a) indicate that Smuts Lake does not stratify with respect to temperature and dissolved oxygen in summer. Surface and bottom temperatures were similar, and the levels of dissolved oxygen were high throughout the water column. Oxygen levels from surface to 4 m depth remained near saturation to supersaturation throughout the summer.

Levels of oxygen in winter (Table 1b) have been adequate for the survival of walleye and yellow perch.

The water in Smuts Lake is alkaline with pH values ranging from 8.56 to 8.8 (Table 1a and 1b).

The Secchi disc transparency in Smuts Lake is usually low (< 150 cm), similar to measurements recorded from other Saskatchewan lakes draining agricultural land (Liaw 1982).

Surface water temperature monitored from the end of May to the end of August (main part of the growing season) for both years ranged from 13.0° C to 26.0° C with a mean of 19.8°C. Surface water temperature dropped rapidly in September, reaching 9.0° by the end of the month:

Table 1a. Smuts Lake open-water season limnological data, 1988-89.

	May 27/88		June 16/88		July 14/88		Oct. 20/88		June 22/89	
Depth(m)	Temp(°C)	DO(mg/l)	Temp(°C)	DO(mg/l)	Temp(°C)	DO(mg/l)	Temp(°C)	DO(mg/l)	Temp(°C)	DO(mg/l)
0.0	18.0	8.2	21.5	9.2	19.0	8.6	6.7	11.1	20.0	9.0
0.5			21.5	9.2	19.0	8.6	6.7	11.1	20.0	8.8
1.0	18.0	8.2	21.5	9.2	19.0	8.6	6.7	11.1	19.0	8.7
1.5			21.5	9.2	19.0	8.6	6.7	11.1	19.0	8.7
2.0	18.0	8.2	21.0	9.1	19.0	8.6	6.7	11.1	18.7	8.7
2.5			21.0	9.1	19.0	8.6	6.7	11.1	18.7	8.6
3.0	17.5	8.0	21.0	9.0	19.0	8.6	6.7	11.1	18.5	8.5.
3.5			21.0	9.0	19.0	8.2	6.7	11.1	18.5	8.5
4.0			21.0	9.0	19.0	7.3	6.7	11.1	18.5	8.4
4.5			21.0	8.9	19.0	6.4	6.7	11.1	18.5	8.0
5.0	16.0	6.0	21.0	8.8	19.0	5.5	6.7	11.1	18.5	7.5
5.5			21.0	8.8	19.0	4.9	6.7	11.1	18.5	5.0
Air-temp	28.0		26.0		19.0		6.0		21.0	
Secchi-depth(cm)			150.0		140.0				233.0	
pH	8.56		8.7		8.76				8.66	

Table 1b. Smuts Lake winter limnological data, 1989 - 1990.

	Jan 13/89		Dec 7/89		Jan 2/90		Jan 24/90	
Depth(m)	Temp(°C)	DO(mg/l)	Temp(°C)	DO(mg/l)	Temp(°C)	DO(mg/l)	Temp(°C)	DO(mg/l)
1	0.0	8.8	1.0	9.9	1.5	7.8	1.5	6.8
2	0.0	8.6	1.5	9.8	2.0	7.6	1.8	6.6
3	0.5	8.3	2.5	9.1	2.0	6.9	2.2	6.0
4	1.0	7.5	3.0	6.8	3.0	6.2	3.0	4.4
5	1.5	5.0	3.0	4.8	3.0	4.8	3.0	3.2
pH	8.8				8.5		8.5	
Snow cover(%)	100		40		100		100	
Snow depth(cm)	10		5		10-15		15-25	
Ice depth(cm)	60		40		60		60	

Date			Temperature (°C)
1988	May	27	18.0
	June	16	21.5
	July	14	19.0
	July	19	20.0
	August	4	21.0
	August	15	21.0
	August	29	19.0
	Sept	27	9.0
	Oct	19	9.0
	Oct	21	7.0
1989	May	29	13.0
	May	30	14.0
	June	22	20.0
	July	5	22.0
	July	17	26.0
	July	18	24.0
	Aug	30	18.0

4.2 Zooplankton and Other Biological Observations

The standing crop of zooplankton was determined because of its importance as a food source for larval and young perch and walleye. The result of three samplings (see table below) indicate that Smuts Lake had a very large zooplankton crop. Among the zooplankters, copepods (nauplius stages excluded) and daphnids are the most important forage base for larval and juvenile walleye and perch because of their larger size. Concentrations of these two groups of zooplankton were higher than that (>100 organisms/L) usually required for successful rearing of walleye in ponds.

Date	No.organisms/L			
	Rotifers	Copepod nauplii	Copepod adults and subadults	Daphnids
May 27	195	15	165	60
Jun 16	326	337	104	22
Jul 14	317	113	138	24

Smuts Lake also had a large crop of phytoplankton and submersed macrophytes (mainly *Ceratophyllum* and *Potamogeton*). Moderate to heavy blooms of blue green algae occurred in the summer.

Large benthos in Smuts Lake consisted mainly of amphipods and various aquatic insect larvae. Numerous amphipods were always found in the various nets that were set in the lake. These organisms provided another important food source for the walleye and perch in the lake.

In addition to the introduced yellow perch and walleye, brook sticklebacks were present in Smuts Lake. They were very abundant, as many were often caught in seine and trapnets. This fish provided yet another forage species for the walleye and perch.

4.3 STOCKED FISH POPULATIONS

4.3.1 Yellow Perch

Population Characteristics

Between June 16, 1988 and August 31, 1989, approximately 4000 perch were caught from Smuts Lake mainly by gill-netting. Several size groups, ranging from juvenile to adult, were found in the catch.

The fork length of a sample of the perch ranged from 5.6 cm to 28.8 cm with a mean and standard deviation of 16.9 cm and 2.7 cm (two juveniles measuring 22 and 25 mm were excluded) The majority (64%) of the fish were in the 15 cm to 19 cm range (Fig. 3).

The weight of the 749 perch measured ranged from 1.6 g to 489 g with a mean of 75 g and a standard deviation of 59 g. Most (84%) of the fish were under 100 g (Fig.4).

About 32% by length and 16 % by weight of the perch measured were considered to be of angling size (i.e. larger than 18 cm in length or 100 g in weight (Durbin 1984).

An examination of the gonad conditions of a sample of fish suggests that the majority of the perch in Smuts Lake mature when they have reached 14 cm in fork length and

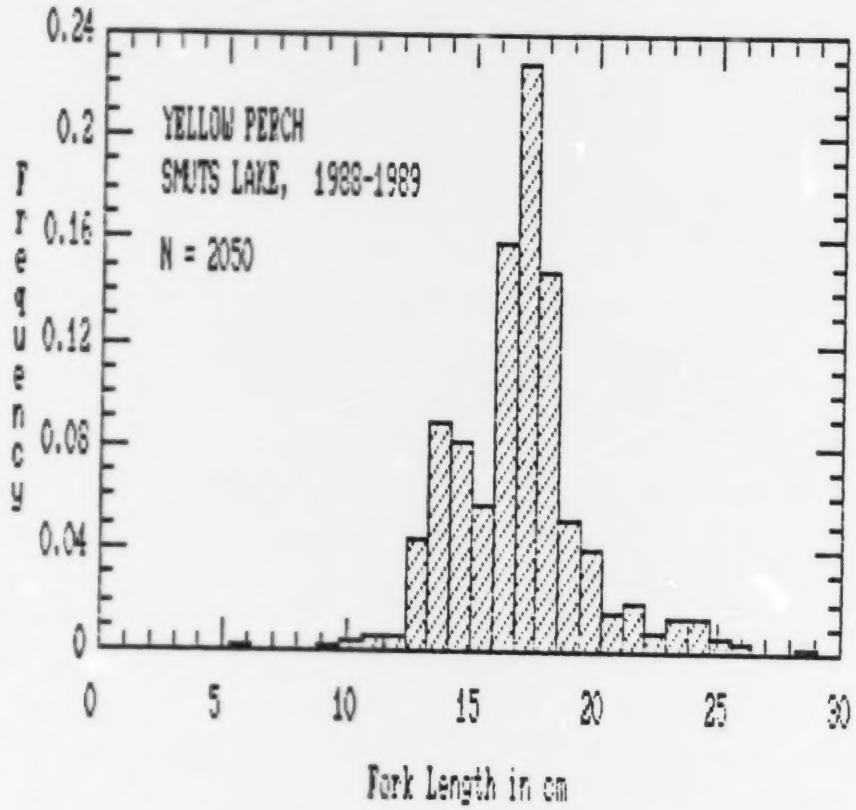

Fig. 3 Length frequency distribution of yellow perch in Smuts Lake.

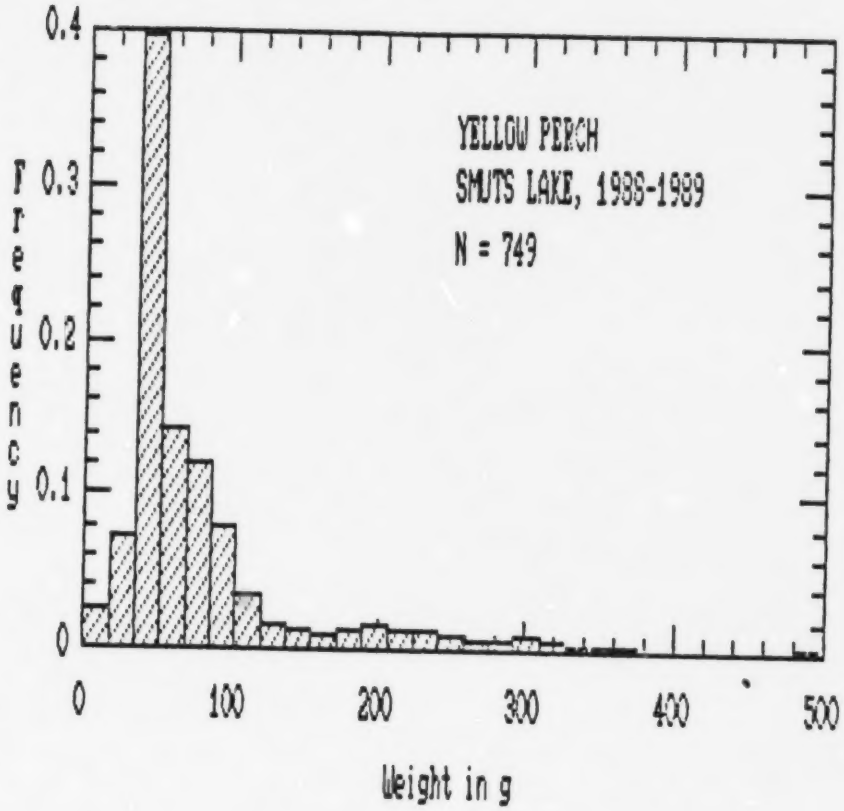

Fig. 4 Weight frequency distribution of yellow perch in Smuts Lake.

about 50 g in weight. The ratio of female to male is close to 1:1, based on the 180 individuals sexed.

The length-weight relationship of Smuts Lake perch is shown in Fig. 5. This relationship with its 95% confidence limits can be used to estimate the weight of a perch from its length, if direct measurement of weight is not available. A separate relationship was not calculated for male or female perch, because relatively few individuals were sexed.

Both fork and total lengths were measured for 370 perch ranging from 9.4 cm to 28.8 cm in fork length and from 9.9 cm to 29.8 cm in total length. A regression equation , TL =0.3683 + 1.0250 FL (r =0.99; standard error of estimate = 0.2230), was calculated. This equation can be used to convert fork length measurements to total length if the latter is required.

Relative weight (Wr) is used to evaluate the condition of the yellow perch in Smuts Lake. Relative weight values are calculated by dividing the actual weight of a fish by a standard weight (Ws) for a fish of the same length, expressed in percentage (Wege and Anderson 1978). Using the Ws equation recently developed by Willis, Guy and Murphy (1989), values of Wr of a sample of 746 yellow perch from Smuts Lake vary from 76% to 153% with a mean of 108%

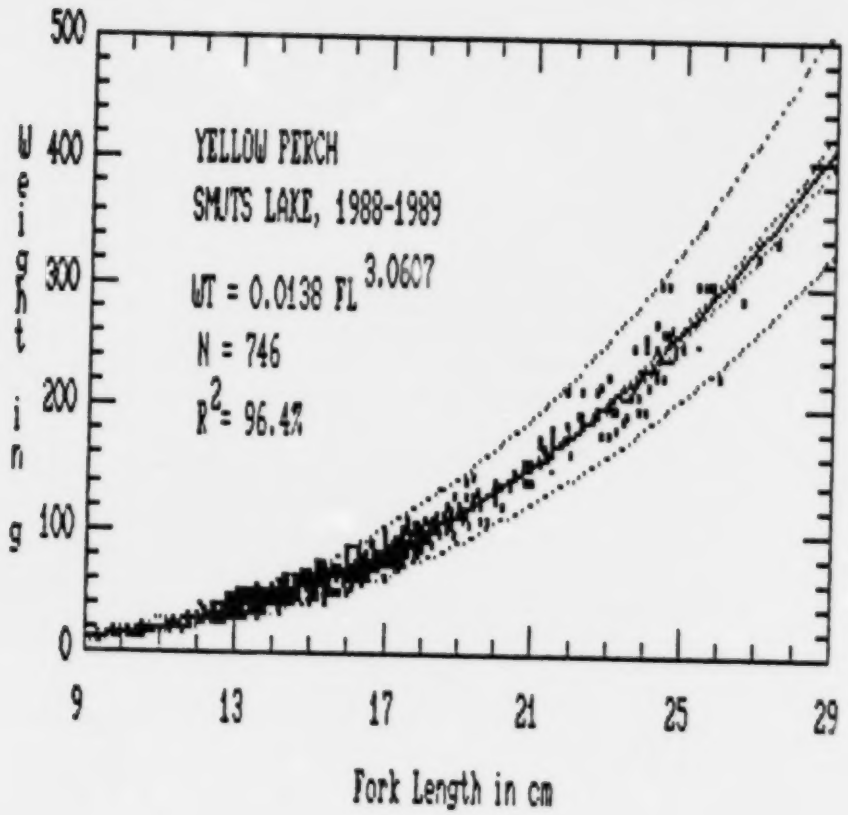

Fig. 5 Length-weight relationship of yellow perch (FL $\geq$ 9.0 cm) from Smuts Lake. Outer and inner dotted lines indicate 95% confidence limits of predicted values and means, respectively.

and a standard deviation of 13%. Nearly all (98%) of the fish measured have a Wr of 95% or greater. Compared with other yellow perch populations in North America, the yellow perch in Smuts Lake can be considered in excellent condition. Fish that have a Wr value of 100 might be considered in "optimal" or "better-than-average" condition (Willis, Guy and Murphy 1989).

Food Habits

Stomach content analysis was carried out on 199 perch caught between June 16 and October 20, 1988. These fish ranged from 2.2 cm to 23 cm in fork length. Of these perch, 60 (30%) had empty stomachs, while 139 (70%) contained food. The percent frequency occurrence of each food item is as follows: insect larvae (mainly chironomid and caddisfly larvae), 66; amphipods, 40; zooplankton (copepods, daphnids and *Bosmina*), 8; and other insects (water boatmen and dragonfly nymphs), 3. Zooplankton was found mainly in the diet of juvenile and fingerling perch, whereas insect larvae and amphipods were found more frequently in the stomachs of larger individuals.

Population Estimates

On June 17, 1988, 666 subadult and adult yellow perch were caught by trapping and seining, marked by removing the left pelvic fin and released. On July 20, 1988, 1216 perch were caught by gillnetting and examined for marks, of which 9 were recaptures. A single census Petersen method (see Ricker 1975) gives a population estimate of 81 174 with 95% confidence limits of 44 847 and 152 348 (the confidence limits are asymmetrical due to use of the Poisson distribution in the calculation. See Ricker (1975), Appendix II).

Between October 19 and 21, 1988, another 572 perch were caught and examined for marks. Four marked fish were found. The data give a population estimate of 75 406 with 95% confidence limits of 15 332 and 135 480.

These two population estimates are similar compared with ranges of the confidence limits. This suggests that the estimates are of the right magnitude. However, the first estimate should be considered to be more accurate, because it was based on a larger sample size and the time elapsed between marking and recovery was shorter.

Based on the population size of 81 174 and the percentages of angling size fish, there were about 25 980 (553/ha) by length and 12 990 (276/ha) by weight angling size perch present in Smuts Lake in the summer of 1988.

4.3.2 Walleye

Growth Rates

Samples of juvenile and fingerling walleye were collected regularly from Codette Pond as well as from Smuts Lake during the growing season for determinations of growth rates and stomach contents. Measurements of length and weight of these fish are presented in Appendices 2A and 2B.

A comparison of the growth of walleye stocked as fry in Smuts Lake and those first stocked as fry in Codette Pond and later transferred to Smuts Lake as fingerlings is presented in Figs. 6 and 7. The growth curves show that increase in size in the walleye is fastest during the first growing season, which lasted about 120 days (from late May to early September). During this period, Smuts Lake fish grew at a rate of 1.2 mm/day in total length and 272 mg/day in weight. By comparison, the walleye in Codette Pond had a growth rate of 1.2 mm/day in length and 63 mg/day in weight during the first 50 days in pond. Their growth dropped considerably before harvest. After restocking into Smuts

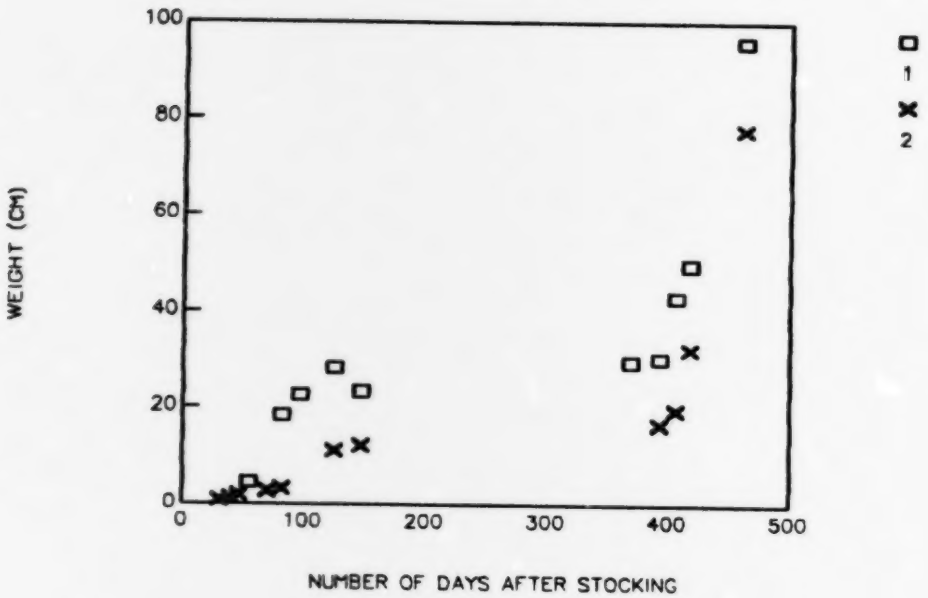

Figure 6. Growth in length of walleye in Smuts Lake.

1 - Stocked as fry on May 27, 1988.

2 - Stocked in Codette Pond as fry on May 27, 1988 and restocked in Smuts Lake as fingerlings on August 4, 1988.

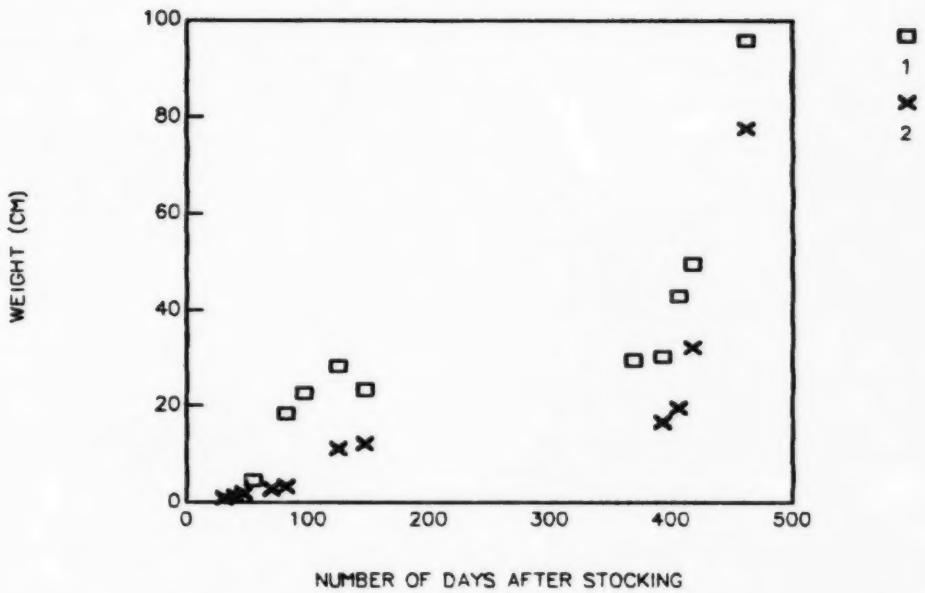

Figure 7. Growth in weight of walleye in Smuts Lake.

1 - Stocked as fry on May 27, 1988.

2 - Stocked in Codette Pond as fry on May 27, 1988 and restocked in Smuts Lake as fingerlings on August 4, 1988.

Lake they grew at a rate of 65 mm/day in total length and 151 mg/day in weight and attained an average size of only 10.8 cm and 11.16 g by the end of the growing season.

Virtually no growth took place during the period from October to May of the following year. During this period, Smuts fish increased only at a rate of 0.04 mm/day and 20 mg/day, whereas, Codette fish did slightly better at 0.07 mm/day and 25 mg/day.

Growth resumed at the baginning of the next summer with much larger daily gain in weight than in length. Although the growth of Codette walleye was slower at the time of restocking, it increased considerably in the second growing season. The growth curve suggests that by the end of the second growing season, the restocked Codette walleye would have almost caught up with the Smuts walleye.

Condition factors (K) of Smuts Lake walleye tended to decline as the fish grew bigger but levelled off at between 0.8 and 0.9 about 70 days after stocking (Fig. 8). The condition of walleye in Codette Pond showed a similar trend, but it declined further to a low level of 0.76 shortly after restocking into Smuts Lake. However, it bounced back to a higher level towards the end of the growing season.

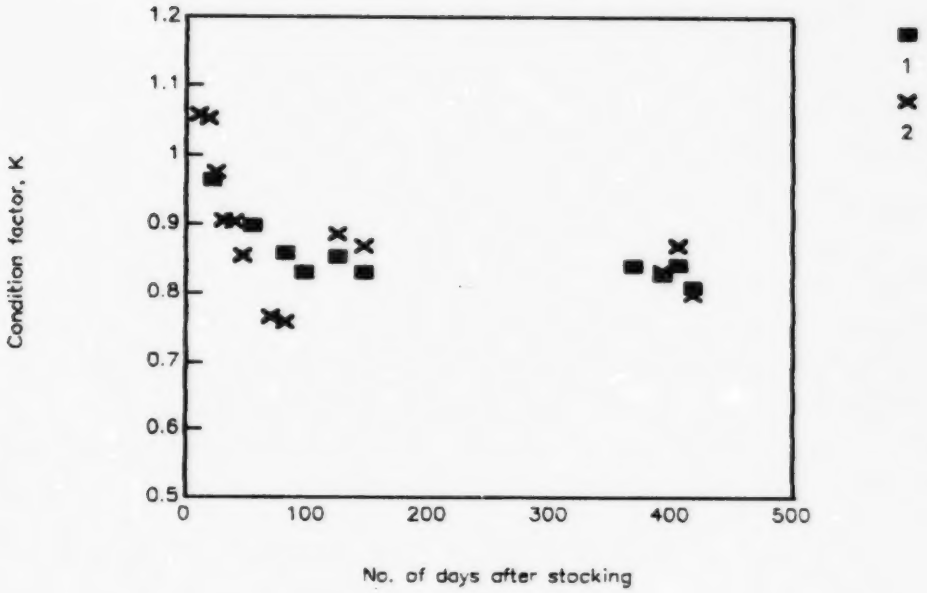

Figure 8. Condition factors of walleye in Smuts Lake.

1 - Stocked as fry on May 27, 1988.

2 - Stocked as fry in Codette Pond on May 27, 1988 and restocked in Smuts Lake as fingerlings on August 4, 1988. Condition factor, $K=(W/L^3)x100$, where W = weight in g, L = total length in cm.

Population Estimates and Survival Rates

All fingerlings from Codette Pond were left pelvic fin clipped before release into Smuts Lake. Recaptures of these fish along with those stocked originally as fry in Smuts Lake permit an estimation of the number of walleye present in Smuts Lake on the day of fingerling stocking (August 4).

In addition, 886 Smuts Lake walleye were marked by removing the right pelvic fin on several occasions. Details of the mark and recapture are presented in Appendix 1.

A total of 80 Codette walleye were recaptured between August 16, 1988 and August 31, 1989. If samples taken between September 28 and October 20, 1988 are excluded, the number of recaptures becomes 76 and the total number of fish examined for marks is 1141. Based on these mark and recapture data and using an adjusted Petersen estimate, the total number of walleye present in the lake on August 4, 1988 was estimated to be 61 712 (including the 4160 restocked Codette Pond walleye), with 95% confidence limits of 49 499 and 76 643. This means that about 58 000 (61 712-4160 =57 552) of the 100 000 walleye fry stocked into Smuts Lake on May 27 had survived to August 4.

The samples taken between September 28 and October 20, 1988 were disregarded in the above calculation, because

the ratios of Smuts to Codette fish in the catch suggest that Codette fish were inadequately sampled during this period (Appendix 1). The ratios of Smuts to Codette walleye indicate that Codette walleye disappeared from the catch about two weeks after being restocked, but reappeared in the samples taken in 1989 in ratios (average 12.6) similar to that in the first catch (12.8). This means that the restocked Codette fingerlings did not suffer large mortalities after restocking as the data obtained in 1988 would have suggested. The data obtained in 1989 suggest that mortalities of Codette fish remained stable after restocking and were similar to those of the Smuts walleye.

Population estimates can also be made on the numbers of marked and recaptured Smuts walleye alone, or on mark and recapture data of both Smuts and Codette walleye, using the modified Schnabel equation (Ricker, 1975). The latter data set gives an estimate of 89 198, while the former gives an estimate of 75 045 (see Appendix 1 for details of calculation).

Of the above three estimates, the first is considered to be more accurate, because it is based on a larger sample size and has narrower confidence limits which are within the range of the number of fry stocked (estimated 100 000).

Food Habits

The results of the stomach content analysis on samples taken in 1988 (Table 2) indicate that the walleye in Smuts Lake fed actively throughout the summer. The percentage of empty stomachs found among samples was relatively low, ranging from 9 to 40 %.

Larvae and pupae of *Chaoborus* were the food items most frequently consumed by walleye fingerlings in Smuts Lake.. The next most frequently eaten food items were chironomid larvae and amphipods (*Gammarus*). These two groups were particularly important in the diet of larger fingerlings.

In addition to *Chaoborus*, juvenile walleye consumed copepods and daphnids, as well as small brook sticklebacks which were abundant in the lake. While daphnids were also eaten by larger fingerlings throughout the summer, copepods and fish were not found regularly in the diet of larger fingerlings.

5. DISCUSSION

Smuts Lake is a fertile water body, draining cultivated agricultural land. It provides a rich and diverse forage base for stocked walleye and yellow perch. This is the key to the success of the stocking of yellow perch in

Table 2. Frequency of occurrence (%) of various food items in the stomach contents of walleye in Smuts Lake, 1988.

Date	June 17	Aug 16	Aug 30	Sept 1	Sept 28	Oct 21
No.fish examined	21	20	4	32	18	36
No. with food	13	12	3	29	15	27
% empty stomach	38	40	25	9	17	25
Total length of fish, mm						
mean	29	129	148	138	149	141
standard deviation	2	7	15	7	11	9
Amphipods	0	33	0	45	20	20
Caddisfly larvae	0	0	0	3	0	4
Chaoborus larvae & pupae	92	83	70	55	7	0
Chironomids larvae	0	42	34	55	93	89
Copepods	23	0	0	0	0	0
Daphnids	15	33	0	59	7	0
Fish	15	25	0	0	0	0
Leeches	0	0	0	7	0	0
Mayfly larvae	8	0	0	0	0	0
Other insect larvae	0	0	0	3	7	0

1982 and the planting of walleye fry in 1988. On the other hand, high fertility can often cause summer kill or low oxygen levels in winter, which can wipe out a successfully established fish population in a matter of days. This had happened in the early years of its fish stocking history.

Although winterkill has not happened since 1982, there is no guarantee that it will not occur again. Therefore, close monitoring of winter oxygen conditions is an essential part of the management of this lake.

The results of the study indicate that the yellow perch stocked in 1982 have survived and reproduced well in Smuts Lake. Values of relative weight indicate that these yellow perch are in good condition. Currently there are about 81 200 subadult and adult yellow perch in the lake. Individuals of angling-size (larger than 18 cm in length or 100 g in weight) are present in moderate numbers, accounting for 32% by length and 16% by weight of the population. This means that there are about 553 (by length) or 276 (by weight) angling-size yellow perch per hectare in Smuts Lake.

Walleye were stocked into Smuts Lake to compare fry versus fingerling stocking. Data obtained so far suggest that with respect to growth, the walleye stocked as fry did extremely well; whereas those stocked as fingerlings did poorly shortly after restocking but were able to improve

later. The survival of the restocked fingerlings can not be assessed from the present data. The fact that the average ratio of Smuts to Codette walleye in 1989 samples is similar to that in the first sample taken two weeks after restocking suggests that mortalities of these two groups of fish remained similar throughout the study period.

The growth of the walleye from juvenile to fingerling size in Smuts Lake (Fig. 5 and 6, Appendix 2A) is probably among the fastest recorded from Saskatchewan waters. By comparison, growth rates of walleye in Saskatchewan rearing ponds average from 0.98 mm/day and 50 mg/day (fertilized ponds) to 1.23 mm/day and 154 mg/day (unfertilized natural ponds) (Liaw 1987, Arsenault 1988). Walleye fingerlings grow faster in unfertilized ponds because of lower fingerling densities. The fast growth of walleye in Smuts Lake is attributable to the presence of abundant food resources and lower fingerling densities (<1400/ha).

In temperate and boreal regions growth of fish tends to have a seasonal cycle, i.e. faster in summer and slower in winter (Moreau 1987). The growth patterns of the walleye in Smuts Lake also show such seasonal cycles (Fig. 5 and 6). However, it is surprising that their growth stopped so early in the fall (end of August) and resumed so late in

the spring (early June). More frequent monitoring of the growth of stocked walleye may provide useful information with regard to growth rates and patterns of walleye populations in Saskatchewan waters.

The growth curves of Codette walleye (Figs. 5 and 6) suggest that growth of walleye in rearing ponds is usually fast within two months after stocking, but may drop thereafter due to lack of food. Although growth may resume after restocking into lakes, it may take more than one growing season to catch up. Moreover, smaller individuals in poor condition may suffer a larger mortality after restocking than larger fish in good condition. Therefore, it is advisable to harvest and restock fingerlings before their growth begins to decline.

The good survival of the walleye stocked as fry suggests that predation and competition from yellow perch was not a problem in Smuts Lake. Stomach content analysis of yellow perch reveals that walleye juveniles and fingerlings were not among the food items eaten by the perch. Predation by perch, if there was any, would have been much reduced because of the presence of very abundant invertebrate food resources in the lake. On the other hand, fish were found in the diet of the walleye. They were all brook sticklebacks. No yellow perch were found in the stomach contents of the

walleye sampled in 1988. The yellow perch were probably too large for the walleye to prey on. However, the situation may change in the future as the walleye outgrow the yellow perch. Then the walleye can be managed as a predator species to control overpopulation and stunted growth in the yellow perch.

6. CONCLUSION

In spite of the presence of a large yellow perch population as a competitor and a potential predator, the walleye stocked as fry in Smuts Lake did well with respect to growth and survival. The walleye from Codette Pond were much smaller when restocked into Smuts Lake. However, shortly after being restocked into the lake, they were able to resume growth at a faster rate. By the end of the second growing season, they almost reached the same size as the Smuts Lake walleye.

The key factor to the success of fry stocking in Smuts Lake seems to be the presence of abundant edible zooplankton and other food bases throughout the entire growing season. Under such circumstances, stocking of fingerlings has no advantages over fry stocking.

7. RECOMMENDATIONS

Based on the above findings, it is recommended that:

1. Investigation on the food supply in the receiving lake be conducted before walleye stocking. If food supply is adequate for newly hatched walleye fry, stocking should be done with fry rather than fingerlings.

2. Harvest of walleye fingerlings from rearing ponds be carried out before their growth begins to decline due to lack of food.

3. Angling of yellow perch in Smuts Lake be encouraged.

4. The walleye in Smuts Lake be managed as an additional angling species, as well as a predatory species to control overpopulation and stunted growth that often occur in yellow perch.

5. Winter oxygen levels in the lake be monitored frequently, and appropriate measures (e.g. snow removal, installation of an aerator) be taken to prevent winter kill when oxygen levels approach the critical level of 2.6 mg/l.

6. Monitoring of the growth and survival of the stocked walleye be continued.

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Appendix 1. Mark and recapture record of walleye fingerlings in Smuts Lake for population estimates.

Date	Number caught				Recaptures		
mm/dd/yy	Total (Ct)	Smuts fish(Cs)	Codette fish	Ratio S:C	Smuts fish(Rs)	Codette fish	Total (Rt)
08/04/88	0	0	0		0	0	0
08/16/88	83	77	6	12.8	0	6	6
08/30/88	4	4	0		0	0	0
09/01/88	42	42	0		0	0	0
09/02/88	33	33	0		0	0	0
09/28/88	252	250	2	125.0	0	2	2
10/19/88	125	125	0		0	0	0
10/20/88	231	229	2	114.5	1	2	3
10/21/88	280	276	4	69.0	1	4	5
05/30/89	36	36	0		0	0	0
06/23/89	303	259	44	5.9	4	44	48
07/06/89	216	203	13	15.6	4	13	17
07/18/89	103	97	6	16.2	1	6	7
08/31/89	41	38	3	12.7	0	3	3
sum	1749	1669	80	12.7	11	80	91

Appendix 1 (continued). Mark and recapture record of walleye fingerlings in Smuts Lake for population estimates.

Date	Number marked			Marked fish at large				
mm/dd/yy	Smuts fish	Codette fish	Total	Smuts fish(Ms)	Codette fish	total (Mt)	Mt x Ct	Ms x Cs
08/04/88	0	4160	4160	0	0	0	0	0
08/16/88	60	0	60	0	4160	4160	345280	0
08/30/88	0	0	0	60	4154	4214	16856	240
09/01/88	0	0	0	60	4154	4214	176988	2520
09/02/88	32	0	32	60	4154	4214	139062	1980
09/28/88	234	0	234	92	4154	4246	1069992	23000
10/19/88	99	0	99	326	4152	4478	559750	40750
10/20/88	212	0	212	425	4152	4577	1057287	97325
10/21/88	249	0	249	637	4150	4787	1340360	175812
05/30/89	0	0	0	886	4146	5032	181152	31896
06/23/89	0	0	0	886	4146	5032	1524696	229474
07/06/89	0	0	0	882	4102	4984	1076544	179046
07/18/89	0	0	0	878	4089	4967	511601	85166
08/31/89	0	0	0	877	4083	4960	203360	33326
sum	886	4160	5046				8202928	900535

Population estimates (see Ricker 1975):

A. Adjusted Petersen estimate, using only Codette fish as marks. However, data obtained between Sep. 28 and Oct. 20, 1988 were excluded because Codette fish were inadequately sampled during this period.

M = 4160 N = 61712
C = 1141 95% confidence limits of N = 49499 - 76643*
R = 76

B. Modified Schnabel estimate, using only Smuts Lake fish mark and recapture data.

N = sum(MsCs)/Rs + 1 = 75045
95% confidence limits of N = 43504 -140 709*

C. Modified Schnabel estimate, using mark and recapture data from both Smuts and Codette fish.

N = sum(MtCt)/Rt +1 = 89198
95% confidence limits of N = 72773 - 109198*

* Asymmetrical confidence limits are due to considering R (recapture) as a Poisson variable (Ricker 1975, Appendix II).

Appendix 2a. Length and weight data of the walleye stocked in Smuts Lake as fry on May 27, 1988.

DATE	GROW DAY	TL(CM)	STD	WT(G)	STD	NO. FISH
07-Jun-88	11					
15-Jun-88	19					
17-Jun-88	22	2.9	0.20	0.235		34
21-Jun-88	25					
27-Jun-88	31					
06-Jul-88	40					
13-Jul-88	47					
20-Jul-88	55	8.0		4.60		1
04-Aug-88	70					
16-Aug-88	82	12.9	0.70	18.42	3.810	15
31-Aug-88	97	14.0	0.86	22.59	6.080	36
28-Sep-88	125	14.9	1.00	28.234	6.422	16
20-Oct-88	147	14.1	0.90	23.34	5.730	74
30-May-89	369	15.2	1.20	29.501	8.533	36
23-Jun-89	393	15.4	1.20	30.233	8.642	257
06-Jul-89	406	17.2	1.20	42.817	9.082	152
18-Jul-89	418	18.3	1.00	49.614	8.113	95
31-Aug-89	462	22.6	1.20	95.779	16.209	38

Appendix 2b. Length and weight data of the walleye stocked in Codette Pond as fry on May 27, 1988 and restocked in Smuts Lake on August 4, 1988.

DATE	GROW DAY	TL(CM)	STD	WT(G)	STD	NO. FISH
7-Jun-88	11	1.7		0.052		75
15-Jun-88	19	2.6		0.185		61
17-Jun-88	22					
21-Jun-88	25	3.6		0.455		68
27-Jun-88	31	4.7		0.94		55
6-Jul-88	40	5.3		1.345		61
13-Jul-88	47	6.1		1.94		62
20-Jul-88	55					
4-Aug-88	70	7.2	1	2.86	0.57	53
16-Aug-88	82	7.6	0.5	3.33	0.66	5
31-Aug-88	97					
28-Sep-88	125	10.8		11.16		2
20-Oct-88	147	11.2	0.5	12.2	1.97	6
30-May-89	369					
23-Jun-89	393	12.6	0.6	16.66	2.06	42
6-Jul-89	406	13.1	0.7	19.55	2.37	13
18-Jul-89	418	15.9	0.5	32.11	2.56	6
31-Aug-89	462	21.2	0.5	77.63	4.45	3